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PREFACE

This summary report reviews activities and accomplishments of the U.S. Grain Marketing Research Laboratory (USGMRL) in FY-1978. Like the previous reports, it concentrates on what happened in the last year. It also provides an appropriate time to take stock of what happened during the last 5 years. We believe that the logical and inevitable assessment is that they were 5 years of sustained and strong growth. That growth involved the addition of several key scientists who made possible the development of a balanced, interdisciplinary program and efficient use of our physical facilities. That growth was made possible by good use of our two strongest assets: (1) the availability, under one roof, of human and physical resources for interdisciplinary research, and (2) the recognition that long-range basic and applied research, responsive to immediate needs, are companions for successful and valuable research. We have found that the time-proven route from new concepts through applied investigations (laboratory, pilot plant, and field) to development of new products or methods is still the best return on the taxpayers' investment in research. Some of our studies were conducted in cooperation with scientists in other U.S. Department of Agriculture (USDA) agricultural research facilities and in several universities. Most of our collaborative studies were with researchers at the Kansas Agricultural Experiment Station and represented effective and mutually beneficial cooperative efforts.

Growth and expansion have been in areas involving cooperation with several action-regulatory agencies in USDA: Federal Grain Inspection Service (FGIS), Agricultural Marketing Service, Animal and Plant Health Inspection Service (APHIS), Foreign Agricultural Service, and Office of the General Sales Manager.

The facts and accomplishments speak for themselves. They are given in the list of publications and oral presentations and are highlighted in the preface.

We have completed the first comprehensive study on the fine structure of the mature rice kernel and have reviewed implications of that structure in grain marketing. The use of microscopy in demonstrating differences among isogenic lines was demonstrated. The usefulness of two biochemical indices of fungal growth was studied extensively. Work was completed and reported on an improved—simpler, faster, and more sensitive—method for determining sprout damage in the laboratory and in the field. The laboratory method, along with other tests used routinely, has been evaluated by collaborators from the main wheat growing and importing countries. The role of wheat flour lipids, alone or in a three-way combination with shortening and surfactants, was demonstrated. And the possibility of improving low-quality breadmaking wheats by judicious combinations of lipids and lipid-like materials was studied.

Our scientists have reported on several accomplishments in the area of insect and mold control. The protoxic molecule of *Bacillus thuringiensis* has been isolated and purified; the isolate retains full insecticidal activity. Pilot plant studies have confirmed that *B. thuringiensis* provides long-term protection from Indian meal moth and almond meal moth. Work on the epidemiology of *Aspergillus flavus* as related to insect infestation and climatic conditions was continued.

A fumigation schedule developed to provide control of possible Hessian fly contamination of U.S. hay exports has been accepted as an official treatment method by APHIS, Plant Protection and Quarantine Programs, USDA. A new, highly active insect growth regulator has been synthesized with the collaboration of Japanese and Danish scientists. Its efficacy is being evaluated. Chitinase, a molting enzyme from insect hemolymph, has been purified and characterized. It is being tested as a possible target for new insecticides. Several vertebrate hypoglycemic and β-cell cytotoxic agents have been shown to possess insecticidal properties toward stored-product insects. A simple, inexpensive "drip-on applicator" for grain protectant application was developed and tested. It should be of particular value in light of the large increase in on-the-farm grain storage. Work in the United States on the control of insects was reported in a Symposium on Prevention and Control of Insects in Stored-Food Products, held in Manhattan, April 9-13, 1978. The symposium was cosponsored by the American Society of Entomology, Kansas State University, and USGMRL. Much of the original planning, technical programming, and arrangements were made by the late Delmon W. LaHue.

This past year has been an exciting one for our engineers. Minimization of fuel requirements for grain drying, namely utilization of solar energy, and evaluation of test results conducted during the last four fall seasons have enabled us to recommend a solar heat in-bin grain drying system. Because of the increase of grain elevator explosions, research on handling, control, measuring-monitoring, and utilization of grain dust was accelerated. Characteristics and utilization methods of grain dust, reduction of dust generation by additives, causes and prevention of grain dust explosions, and reduction of grain damage from handling were intensively studied. The work is well under way, and the results will be reported in the usual channels (scientific publications, meetings, news media) and in an International Symposium on Grain Dust—Its Characteristics, Explosibility, Hazard Control, and Utilization—Where We Are and Where We Are Going. We are planning to hold the symposium in Manhattan, October 2-4, 1979. It will be cosponsored by USDA's Federal Grain Inspection Service, National Grain and Feed Association, Grain Elevator and Processing Society, and Kansas State University.

A four-point self-leveling spreader to fill grain bins was designed and constructed to produce uniform distribution of grain. Experiments on distribution of fine materials and broken kernels and pressure drop through the grain beds were conducted, and a mathematical model was developed to predict the results.

Over the years, our Hard Winter Wheat Quality Unit has made recognized contributions to unravelling the mysteries of breadmaking potential, to developing new testing methods, and to evaluating thousands of new wheat selections and cultivars each year. A team effort, in cooperation with State and USDA geneticists, plant breeders, plant pathologists, entomologists, chemists, and food technologists, has produced much improved wheat cultivars. Varieties released during the last decade have an excellent combination of agrotechnical and functional (in milling and breadmaking) properties. Improvement in protein quality has been so great that today acceptable bread can be produced from wheats containing up to one percentage point less protein than 10 years ago. The high cost of fertilizers, the increase in yields, and the desirability of high-protein wheats in breadmaking make increasing protein content mandatory in high-yielding wheats by genetic means. We are proud to be part of a program involving USDA, State, and private plant breeders that has produced several new and agrotechnically acceptable

cultivars with up to 2.5 percentage points more protein than in present cultivars. That work has continued in FY 1978. In addition, our scientists have studied and reported what needs to be done to make milk solids in breadmaking acceptable to lactose-intolerant consumers. Fine progress has been made in demonstrating the physical, biochemical, and functional (breadmaking) properties of wheat protein fractions. We have shown that methods developed to evaluate U.S.-grown wheats are equally useful in evaluating wheats from plant-breeding programs in other countries.

A collaborative study was conducted to determine the interlaboratory and intralaboratory reproducibility of protein determination in hard red winter (HRW) wheat by Kjeldahl and near-infrared (NIR) procedures. On the basis of this work, FGIS began in May 1978 to use the NIR procedure to analyze for protein in HRW wheat in marketing channels.

A grain acceleration device was designed and built. It impacts grain against grain at velocities that are comparable to those attained by falling grain in an elevator. The device was found useful in differentiating between sound and damaged grain.

A rapid, simple, and objective method, based on measuring the conductivity of an alcohol-water extract of whole rice grains, was developed to measure the degree of milling of rice. The method that is designed to replace subjective rating will be evaluated in a collaborative study.

The value of our research depends on its acceptance by the target recipients. That acceptance involves an economic assessment of cost and impact. We are gratified by the fine cooperation of the scientists located at the USGMRL from USDA's Economics, Statistics, and Cooperative Service. Their continued evaluation of the economic feasibility of several of our programs adds an important dimension to our work.

Hindsight is always so much better than foresight. A retrospective look at the last 5 years, in general, and at the last year, in particular, indicates a lot of foresight, in planning, to make the hindsight so impressive. While we have come of age, we have remained youthful in dedication and in quantity and quality of research productivity. The excellence of our scientists has been recognized by numerous invitations to present lectures, appointments to editorial boards, selections to organize national and international symposia, and appointments to act as scientific editors of prestigious series of advances. The number of visitors to our laboratories has increased significantly, and some of the groups are listed later in this report. Distinguished visitors of varied scientific professions from 58 countries throughout the world and from 36 states in the United States came to see our research facilities and to acquaint themselves with our activities, to share their thinking with us, and to consult with our scientists about novel approaches and new developments. Their stays ranged from a short visit to a year of research work. Those visits, along with innumerable requests for information, interviews, lectures, and participation on committees, acknowledge our diversified activities as a Center of Grain Marketing Research.

Y. Pomeranz
Director, USGMRL

CONTENTS

GRAIN STRUCTURE AND COMPOSITION UNIT

Scientists in this unit conduct investigations to (a) identify composition of cereal grains in relation to storage, handling, utilization and nutritional value; (b) determine relation of cereal grain structure to storage, handling, and utilization; (c) determine use of enzymes in determining composition, structure, storability, and damage during handling of cereal grains; (d) identify, control and eliminate mycotoxins from cereal grains; and (e) assay the protein contents and biological value of cereal grains, in particular, maize and sorghum.

Grain Composition

The approach in these studies is to determine protein, lipid, mineral, and carbohydrate contents and interaction products among grain components as they relate to storage, handling, utilization, and nutritional value. The studies are designed to provide information, on composition of cereal grains, to other units in the U.S. Grain Marketing Research Laboratory (USGMRL) in investigations on the effects of composition on handling, storage, end-uses, nutritional value, and development of quality tests. Studies in this area include determination and characterization of lipids, including the role of lipids in bread-making, interaction between lipids and proteins, and determination and characterization of proteins. The information has been used in the development of nutritionally-improved, consumer-acceptable baked products.

Grain Structure

Cereal grains and products of their processing are studied by microscopic methods—light, scanning electron, and transmission electron microscopy. These studies are designed to correlate grain structure with market quality investigations conducted in other research units in the Laboratory. Studies in this area are comprehensive investigations on the structure of cereal grains, changes in the structure of dough and bread, structure of dough and bread from flours varying in breadmaking quality, and relation of grain structure to handling (corn breakage), storage (damage by molds and insects), end-uses, nutritional value, and development of quality tests.

Use of Enzymes

Enzymes are used to determine composition (proteins, carbohydrates, lipids, glycolipids, lipoproteins, and glycoproteins) and nutritional value of cereal grains, including availability of nutrients and their modification during handling, storage, and processing. Enzyme activity is assayed to determine grain quality (sprouting, deterioration during handling, and storage). The studies are designed to provide information on composition, as determined by enzymatic assays, and on levels of enzymes in cereal grains to other units at the Laboratory for soundness, characterization, and development of quality tests. Enzymes will be used to determine, selectively and specifically, trace amounts of nutrients or contaminants in mold, insect, or rodent infested grain. Studies in this area include sprout damage, differences in alpha-amylase in sprouted wheats and malts from various classes and locations, and developing a mobile unit for field determination of alpha-amylase.

Mycotoxins

Research is conducted to develop analytical procedures, preferably suitable for use in grain marketing channels; to detect specific fungal components as measures of extent of invasion, mycotoxins, and other fungal metabolites; and to identify fungi-grain interrelationships that may regulate invasion of particular grain types, varieties, or hybrids by specific genera or species of fungi. The approach used in these studies is to apply optimized extraction and chromatographic techniques and to simplify and make more effective initial extraction, clean-up, and final detection steps. Metabolites are evaluated as measures of fungal invasion on grains and are compared with mycological and other tests such as discoloration, germination, fat acidity, and odors. Differences in susceptibility to invasion by fungi among grain types, varieties, or hybrids, especially sorghum, are investigated.

Corn and Sorghum Quality

The studies are conducted in a laboratory that assays the protein content and chemical score (based on amino acid contents) of corn and sorghum. In

addition, the laboratory compares various methods for routine determination of protein content and quality in samples from plant breeders and from commercial channels.

BIOLOGICAL RESEARCH UNIT

Insects and microorganisms are the principal kinds of organisms that adversely affect the quality of grain. Insect and microbial activity in stored grains decrease germinability, discolor part or all of the seeds or kernel, cause weight loss, reduce the nutritional value, produce heating, and increase moisture. The latter two factors, in turn, bring about physical, chemical, and physiological changes in the grain. Some insects feed on whole grain, others on broken kernels, thereby increasing the percentage of broken kernels and dockage. Some microorganisms produce toxins that are injurious to man and to domestic animals. Grain and cereal products are subject to insect and microbial infestation, damage, and contamination while in the marketing channels. The Federal Government, the food storage, transportation, and processing industries, and the consumer suffer large monetary losses from grain insects causing damage and downgrading and making the products unfit for human consumption. The presence of insects and the damage done by them affects us adversely in the highly competitive foreign market.

Another cause for concern in relation to foreign trade in grain is that pesticide and fumigant residues are receiving increasingly critical scrutiny in the European Common Market countries as well as in other parts of the world. Insects and pesticide and fumigant residues are of concern also for the domestic market. Need is urgent for more acceptable and effective methods for preventing insect damage and contamination during storage, handling, processing, packaging, transportation, and retail distribution. The need is critical for effective pesticides and application methods that can be used in our domestic and foreign markets without leaving objectionable residues. Even more desirable is the development of effective preventive and control measures using biological, physical, mechanical, or other nonchemical means that would reduce or completely eliminate the application of pesticidal chemicals.

The Biological Research Unit is concerned with fundamental and applied biology of insects and microorganisms that infest stored grains and cereal products. Its primary mission is to gain adequate knowledge of such organisms and the storage environment to develop appropriate techniques and methods of pest management under experimental and practical conditions. Research is divided into the following areas:

Insect Biochemistry and Physiology

The growth and development of stored grain insects is studied to determine unique biochemical and physiological processes that are potential targets for new insect control agents. This approach to insect control uses a class of insecticides called biorational because of their specificity to insects and because they exhibit little or no adverse effects on man, wildlife, domestic animals, and the ecosystem. The program includes basic research in insect biochemistry, endocrinology, and morphology, and applied research in the development of biorational compounds that specifically inhibit particular aspects of an insect's physiological and behavioral processes. Compounds receiving special attention are insect growth regulators with hormonal activity (juvenile hormone, molting hormone, glucagon, and insulin) and those that interfere with exoskeleton production, energy metabolism, reproduction, and sensory perception. The susceptibility of strains of the confused flour beetle, red flour beetle, lesser grain borer, rice weevil, granary weevil, maize weevil, sawtoothed grain beetle, cigarette beetle, Indian meal moth, and navel orangeworm to these chemical agents is being investigated.

Pesticide Biochemistry

Studies are being conducted to develop new insecticidal formulations from chemicals that exhibit low mammalian toxicity as substitutes for approved chemicals currently used. Problems exist in retaining effective control of stored grain insects because some species are developing tolerance and resistance to present-day pesticides. Basic and applied research is directed toward establishing efficacy of new chemicals as grain protectants, as residuals, and as vapor toxicants in addition to determining the concentration of residues remaining after application; measuring the response of insects to varying amounts of insecticidal materials applied to grain during an extended time; and elucidating the mode of action of certain organophosphorus compounds

in insects. The effects of these compounds on *de novo* protein and nucleic acid synthesis and other cellular metabolic functions are being investigated using cultured embryonic cells of the Indian meal moth.

Insect Pathology

Methods for using microbial insect pathogens to prevent and control insect infestations in stored grain and processed products are under development. Basic and applied research entails studies of the structure, physiology, and mode of action of selected bacterial and viral insect pathogens; susceptibility of strains of the Indian meal moth and almond moth to *Bacillus thuringiensis* and granulosis virus, differential toxicity of *B. thuringiensis* isolates, and efficacy of commercial formulations of *B. thuringiensis;* structure, toxicity, and biosynthesis of the entomocidal protein of *B. thuringiensis;* and effects of commodity characteristics, storage environment, biology and behavior of the target insect species, development of resistance to pathogens, and interactions with unaffected insect species on the use of insect pathogens for stored grain insect control.

Pest Bionomics

Research in this area is being conducted to determine the influence of inert atmospheres, produced by exothermic inert atmosphere generators, on toxicity, fecundity, fertility, and development of the major stored grain insects. Other studies include examining the influence of temperature and moisture on the response of insects to the atmospheres produced by an exothermic inert atmosphere generator; the effects of applying modified atmospheres to bulk stored commodity ecosystems including insect populations, functional and biochemical properties of the treated commodity, and fungistatic activity; and the current costs of conventional chemical treatment of grain compared to the costs of installing and operating exothermic inert atmosphere generators for the control of insects in bulk stored grain in cooperation with Economics, Statistics, and Cooperatives Service.

This program also includes a study to identify biological problems, both insect and microbial, associated with environments that occur in transported grain and that contribute to physical losses, quality reduction, and increased transportation costs.

Genetic Resistance in Seeds

Basic and applied biology is being done with grains that exhibit preference, antibiosis, and tolerance to insects and microorganisms. Specific attention is being given to naked and hulled barleys and to several wheat varieties that exhibit differences in their response to certain insects and fungi. For those grains found to be resistant, efforts are being made to determine the site in the grain and the cause(s) of resistance. Planned work will involve genetics of resistance, hybridization techniques to combine resistant genes in seeds with desirable agronomic characters, resistance tests in advanced generation hybrids, and evaluating resistant grains in laboratory and field trials. Specific lines of work will include isolating, purifying, identifying, and evaluating chemical constituents of grains that repel or attract insects and microorganisms and determining genetically controlled structural and morphological characteristics of resistant grain varieties.

ENGINEERING RESEARCH UNIT

The Engineering Research Unit develops and improves techniques for handling, conditioning, and storing grain. These developments enhance the maintenance of quality, order in marketing, and use of grains. Increased industrial and commercial demands for grains, and expanding export market, recent disasters in grain elevator explosions, and increasing stringent quality and safety standards, have created unprecedented problems in handling and conditioning large volumes of grains. Technological changes in grain production and harvesting, the current emphasis on environmental and fuel conservation, and mishaps in grain elevators have added to the complex problems faced by the grain trade and researchers working in this area. Recently, considerable effort has been devoted to determine the causes of dust explosions and to develop methods for control and prevention of dust explosions. Specifically, researchers conduct work on (1) minimizing fuel energy required for grain drying, (2) measuring and controlling dust from grain handling, and (3) reducing damage to grain from handling. Recent progress in these areas of research is summarized as follows:

Minimizing Fuel Energy Required for Grain Drying

Natural air in-bin grain drying systems with and without solar heat from an experimental solar collector unit were used to dry comparable lots of wet harvested grain. Evaluating the results from those tests conducted during the last four fall seasons provided a basis for recommendations of a solar heat in-bin grain drying system.

The factors considered in grain drying include energy use, drying capacity, and maintenance of grain quality. The area of production, grain maturity, harvesting technique, and weather conditions were all factors considered in selecting drying equipment and handling and storage facilities. Solar heat added to natural air drying systems caused the greatest increase in drying rate during cool or cold weather. Wet humid weather during warm drying periods caused mold development. Broken corn and fine and foreign material in bins of high-moisture corn caused uneven airflow and required longer drying periods with greater energy input. Removing fine material from harvested corn by a rotary grain cleaner improved the uniformity of airflow and allowed more uniform drying.

Performance and effectiveness of different experimental solar heat collector systems developed for in-bin grain drying demonstrated advantages for using solar energy. The drying time (days of fan operation to acquire a satisfactory grain moisture content) was directly dependent upon airflow rates and weather conditions. The electrical energy input for fan operation doubled when the grain depth was doubled.

Air heated by different experimental solar energy collector systems contributed 4 to 23 percent more drying than natural air drying. Solar collector efficiency was largely dependent upon airflow velocity over absorbing surfaces and collector size and orientation. Airflow velocity over the absorber surface should be 1,200 to 1,500 feet per minute for solar heating the air. The collector size varied with design of the collector; however, a surface collection area equal to drying bin floor area is recommended.

A combination solar collector and rock pile heat storage unit was constructed using 30 tons of fist-sized limestone rock as a heat storage medium. The mass of the rock used was equivalent to 1.5 times the mass of wet grain. This system caused the period of maximum temperature rise in the drying air to occur 4 hours after sunset and maintained a high grain temperature throughout the night. The effectiveness of the system increased with seasonal cold weather and resulted in 16 to 30 percent more drying than natural air drying systems. The energy input was low because of low airflow resistance through the rocks.

Another way of storing solar and atmospheric heat was to use a bin of previously dried corn. A fan pulled heated air from a suspended plate collector during 8 hours of sunshine and supplied the heated air to the dried grain. The storage bin fan was then turned off, the fan intake covered, and the wet bin fan intake adjusted to pull air for the next 16 hours through the bin with the heat-stored dry grain. This technique provided low airflow to the wet grain using atmospheric air warmed during the hours when the temperature was low and the humidity high. An amount of dry corn used for heat storage equal to the amount of wet corn to be dried provided enough heat storage for the 16-hour cycle. Heat storage capacity of corn was about twice that of rock because of higher specific heat for corn (about 0.4 Btu/lb/°F for corn and 0.2 Btu/lb/°F for rock). Overall drying time for the wet grain was reduced 25 percent while the electrical energy input requirement for both bins was about the same as that for drying a single bin of corn without solar-heat storage.

Another application of heat storage in grain was in-bin drying of wet grain. The first batch of wet grain should not exceed 2 to 3 m in depth, and the fan should operate continuously for 1 week. Another layer (3 m depth) of wet grain was added to the bin, and the fan was operated continuously for 2 to 3 additional weeks. The first dried layer provided the heat storage and low relative humidity control for drying the second layer of grain.

Measuring and Controlling Dust from Grain Handling

Regulations that govern the permissible levels of particulate emissions are causing large grain elevators to increase their dust control efforts. The dust that is separated from grain increases shrinkage and creates dust handling and storage costs.

From 1958 to 1975 an average of 8 grain elevator dust explosions occurred each year in the United States, with a total of 36 persons killed and 211 injured. The export elevator explosions in December 1977 in Westwego, La., and Galveston, Tex., claimed 53 lives and more than 60 were injured. In response to the increase in the number of grain elevator explosions, the Engineering Research Unit

at USGMRL has accelerated the pace of research on handling, control, and utilization of grain dust.

As dust control systems become more sophisticated, the need for dust management becomes necessary. A logical approach toward dust management is to treat grain dust as a by-product that can be used as feed, fuel, or fertilizer. The first step in determining the best use for dust is to determine its properties.

Particle size distributions of dust separated from various grains by current dust control systems were approximately log normal and ranged from 5mμ to 5,000 mμ. Some effluents contained quantities of large material that had capture velocities in excess of 1.3 m/sec. Dust samples were nonuniform, and varying amounts of noncombustible material were concentrated in the fine dust. Coarse dust and combustible fractions of fine dust had nutritional values similar to those for grain; however, the dusts generally contained more fiber. Trace element analyses for calcium, iron, manganese, zinc, copper, arsenic, and lead revealed higher levels in dust samples than in the corresponding grain, but the quantities of arsenic and lead did not exceed allowable limits when used as animal feed. Cobalt, iodine, and mercury were not detected in any dust samples. The specific density and the heat of combustion for fine dusts were inversely proportional to the ash content.

Surface area, pore size distribution, and void volume for samples of dust from wheat, corn, sorghum, and soybeans were measured. An N_2 isotherm at liquid N_2 temperatures using the flow system was estimated at 0.6 m^2/gm.

In studying the mechanism of a grain dust explosion, a sample of grain dust (20 mg) with a mean diameter of 10 mμ was shock heated in a manner identical to that used with similar sized coal dust samples. The mode of ignition of grain dust appeared to be identical to that of coal dust.

Tests for residual gases resulting from fumigation were conducted to detect CCl_4 and CS_2 concentrations in the air after fumigation. Three experiments, at grain temperatures of 40°, 60°, and 80° F, were conducted, and samples of the air were collected at the bottom, center, and top of the leg in the USGMRL elevator. The ratio of CCl_4 to CS_2, which initially was 4:1 (80/20), was 23:1 at 40° F. No fumigant was detected in the air at 60° F and 80° F.

The equilibrium moisture content of grain dusts was determined by two methods. The first method utilizes the principle that water molecules diffuse to or from dust particles in an evacuated jar until equilibrium is reached. The equilibrium moisture content of the dust sample was obtained by measuring the vapor pressure, temperature, and moisture of the grain dust at the equilibrium condition in the jar. The second method utilized a climate control chamber. The equilibrium moisture content was calculated by continuously monitoring the weight change of the dust sample inside the chamber.

We have tested the use of water to prevent dust emission during grain handling. Using a set of spray nozzles set up at the end of a spout, we found that the amount of dust emission was substantially reduced. However, water had to be applied every time grain was handled and only when the grain was dry. By applying 1 percent of water to grain, the moisture of grain increased 0.5 percent, and 0.5 percent evaporated and condensed on the dust particles.

A set of systematic bench scale dust explosion tests designed to measure minimum ignition temperature, minimum ignition energy, maximum pressure rise, maximum rate of pressure rise, and minimum concentration of dust for an explosion, were conducted using a Hartmann bomb. The data corroborated those published previously by the Bureau of Mines.

Two cooperative research projects on utilization of grain dust have begun. One is microbial transformation of grain dust to single cell protein, the other is extrusion processing of grain dust. We are also conducting tests on composting and burning grain dust.

Reducing Damage to Grain from Handling

Broken grain resulted in a nonuniform mixture that had a higher resistance to airflow than whole grain. Nonuniform distribution of broken grain resulted in nonuniform airflow, which contributed to bacterial activity and hot-spot generation in a grain mass. A four-point self-leveling rotating spreader was designed to fill bins to produce uniform distribution of grain. The spreader greatly increased the uniformity compared with that resulting from use of a single point grain spreader.

Experiments were conducted on a loosely filled column of corn mixed uniformly with broken grain and fine material. The studies showed that a pressure drop, up to about 20 percent, increased linearly with increased broken grain and fine material. Predicted pressure drops were similar to ob-

served pressure drops across beds for various percentages of fine and whole corn and for an airflow range of 0.076 to 0.381 m/sec.

A mathematical formulation was developed for steady state axisymmetric, incompressible Darcy flow of fluids through granular materials such as corn. Basic assumptions were Darcy's law and the continuity equation. The equation for the pressure field in the bed is a Laplace equation with a set of approximate boundary equations covering aeration situations; the equation was solved analytically and a pressure field obtained. The theoretical expressions developed were used to determine pressure and velocity at any point in a grain bed with uniform distribution of broken grain and fine material. A correlation was proven to exist between theoretical and experimental pressure fields. This is the first time in the agricultural process engineering field that a direct solution of the Laplace equation has been obtained to cover aeration of grain. Application of this analysis greatly enhances our knowledge of aeration of grain. For a non-Darcy flow condition through a bed of corn having non-uniform distribution of fine material, a numerical technique was used to determine the pressure and velocity at any point in the grain bed.

GRAIN QUALITY AND END-USE PROPERTIES UNIT

Activities in the Grain Quality and End-Use Properties Unit are concerned with (1) identifying physical and structural characteristics and chemical components that govern or are associated with functional properties, (2) developing, improving, or evaluating (or all three) methods and instruments that can be used to objectively, rapidly, and accurately characterize and evaluate grain in domestic and export marketing channels, and (3) cooperating with plant breeders throughout the Great Plains and with agronomists, plant physiologists, entomologists, and biochemists at Kansas State University by providing milling, baking, and biochemical expertise and support for selective projects of mutual interest. Specifically, researchers

(a) Determine and evaluate the functional (milling and breadmaking) properties of early generation and potentially new hard winter wheats bred for the Great Plains and evaluate the earliest feasible generation of hard winter wheats bred for genetically high-protein content. Kjeldahl (protein) analytical equipment and the 10-g mixograph, together with micro- and macro-milling and breadmaking equipment, are employed to determine functional properties of about 2,500 plant breeders' samples (10 g to 1,500 g).

(b) Develop new methods and techniques of determining chemical, milling, breadmaking, physical-chemical, and biochemical properties of hard wheats.

(c) Develop energy-conserving baking methods and high-protein nutritionally improved breads and evaluate nutritionally superior foreign proteins for bread production by applying the recently developed no-sugar formula and short-time (70-minute) technique for breadmaking to high quantities of soy flour singly and in combination with other nutritious foreign proteins such as soy isolates, whey products, casein, nonfat milk solids, and gluten. Optimize baking techniques, oxidizers, and surfactants that may be a function of protein composition and interaction. Study the effect of above- and below-normal fermentation temperatures on malt requirement, fermentation time, proof height, proof time, and oxidation requirement in optimizing dough handling properties, loaf volume, and internal and external bread characteristics.

(d) Conduct studies that will reveal basic concepts of hardness in wheat.

(e) Develop physical and biochemical fractionating and reconstituting techniques to relate functional (breadmaking) to biochemical properties of wheat-flour components and determine the chemical fractions and components of wheat responsible for quality differences. After literally taking the flours apart, corresponding gluten-protein, gliadin- and glutenin-protein (modified and unmodified), and other wheat-flour fractions of good- and poor-quality wheat flours are interchanged, one at a time and in combinations, in the reconstituted flours. Fractions and reconstituted flours are characterized by physical, biochemical, and breadmaking techniques.

Research during the past year has been in the following areas:

Determining and Evaluating Functional Properties of Potentially New Hard Winter Wheats

About 385 samples (1,500 g) of agronomically promising new varieties and recent releases of hard winter wheat were characterized and evaluated in terms of their functional properties including wheat hardness; bolting properties and flour yield; flour

ash; dough mixing, oxidation, and water requirements; bread crumb grain and color scores; and loaf-volume potentialities. About 24 percent of the samples had good milling, chemical, breadmaking, and physical-dough properties. Leading commercial wheat varieties of tomorrow are among them. A number of progenies, in addition, had genetically high-protein contents.

About 1,175 samples (8 g) of the earliest generation crosses, bred in Kansas for genetically higher protein contents than those of the present commercially grown varieties of wheat, were screened for protein content. About 418 progenies contained 1.5 to 5.3 percentage points and 67 contained 3.0 to 5.3 percentage points more protein than their controls.

About 1,220 small samples (40 to 100 g) of early generation progenies of hard winter wheats were micro-milled and evaluated for milling. Each sample of flour was subjected to certain analytical, water-absorption, and mixogram tests. About 275 (23 percent) had promising overall functional properties. Also, 113 of the 275 promising ones had 1.5 to 5.4 percentage points and 45 had 2.5 to 5.4 percentage points more flour protein than their controls.

Genetically High Protein Hard Winter Wheat

High-protein wheats are of utmost importance to wheat growers and processors in the United States and wheat-importing countries. Hard winter wheats have been bred for increased yields at the expense of protein content, which now is a limiting factor in domestic and export requirements. Only about 40 percent of the hard winter wheat grown in the United States is used domestically. At present, baker's flour contains 11.0 to 11.25 percent protein, instead of the 12.5 percent of 25 years ago, and can be used only because the decrease in flour-protein content has been offset by improved protein quality for breadmaking. Nevertheless, about 11.0 percent of protein probably is the minimum needed to insure satisfactory dough machinability and other physical dough properties. Thus, we need new, high-protein hard winter wheat varieties that contain about 2 percentage points more protein than most present commercial varieties.

Developing varieties of hard winter wheat that have high levels of protein as well as high yields and other desirable agronomic properties is of significant nutritional, economic, and ecological importance. Increasing the protein content of wheat could help millions of human beings throughout the world obtain more protein in their diets. Future supplies of crop fertilizers probably will be increasingly scarce and costly, and because protein content is a limiting factor in bakery products at home and abroad, lessened dependence on fertilization for producing high-protein wheats would be beneficial to growers and consumers alike.

Constructing Efficient and Safe Crucible Trays and Tongs for Muffle Furnaces

Ash contents of wheat, wheat flour, and other cereal grains and flours often are determined on 25 to 50 samples at a time, depending on the laboratory. Crucibles containing samples, however, often are placed into and removed from the ash muffle one or two at a time. Such a procedure is time consuming and inefficient and, with most tongs, is uncomfortably hot and hazardous for the operator.

We have developed a stainless steel tray that prevents 10 crucibles from tipping and sliding and special tongs that firmly and safely grip each tray with its crucibles before inserting and removing from the muffle furnace. The trays, when paired one above the other, and the tongs greatly increase the capacity of the muffle and the efficiency and safety of making wheat and flour ash determinations.

Determining Coumestrol in Soybeans by High Performance Liquid and Thin-Layer Chromatography

Coumestrol, an estrogenic compound found in many forage plants, was quantitatively determined (0.1 to 100 ppm) in soybean (*Glycine max* L. Merrill) extracts by high performance liquid chromatography (HPLC). The extraction procedure required 3 hours and the HPLC analysis, 12 minutes. A quantitative estimate of coumestrol in the extract was made by thin-layer chromatography in 25 minutes with a sensitivity limit of 10 ppm and in 2 minutes for a sensitivity of greater than 50 ppm.

Functional Properties of High-Yielding European Wheats Grown at Manhattan

The baking method that previously has been described (*Bakers Digest* 51: 28-30, 32-34, 36. 1977) to evaluate U.S. wheat varieties was equally effective for high-yielding, low-protein wheat varieties grown in Europe. Also, mixograph mixing time was highly effective in differentiating and evaluating the breadmaking properties of those wheats. Variable

environments and particularly low-protein contents (average about 9.5 percent) of those samples, undesirable conditions for evaluating relative functional properties, were eliminated by growing most of the European wheats at Manhattan, where their wheat-protein contents averaged about 13.5 percent. Their milling and baking properties were compared to those for the samples previously grown in Europe.

Hydrolyzed Lactose in Bread for Lactose Intolerant Consumers

Hydrolyzed lactose can be used in bread production as a source of fermentable sugars and to produce lactose-low bread for lactose-intolerant people. Dry milk products can be used in which lactose has been almost completely hydrolyzed enzymatically to glucose and galactose in the production of consumer acceptable bread. If the milk solids (4 g per 100 g flour) are used in the production of such bread, the contribution of glucose to panary fermentation must be supplemented by sucrose, malt, or both, to provide adequate levels of fermentable sugars. For use of lactase-hydrolyzed milk solids, the milk must be heat treated under conditions comparable to those in regular milk powder used in bread production.

Physical and Biochemical Properties of Wheat Protein Fractions Obtained by Ultracentrifugation

High speed centrifugation (100,000 × g and 435,000 × g) was used to partially separate the protein species present in lactic acid solubilized glutens washed from hard winter wheat flours that had good or poor functional (breadmaking) properties. The proteins from each flour sample were separated into several fractions that were characterized by biochemical methods. The high-molecular-weight proteins from the poor-quality flour sedimented faster than those from the good-quality flour. Protein-fraction differences and similarities, within and between the flours of good or poor functional properties, were highly significant.

Functional (Breadmaking) Properties of Wheat Protein Fractions Obtained by Ultracentrifugation

Glutens were washed from hard winter wheat flours that had good or poor functional (breadmaking) properties. Gluten proteins, solubilized in 0.005 N lactic acid, were separated by ultracentrifugation into fractions, depending on certain physical and biochemical criteria. The corresponding gluten protein fractions from the good and poor quality flours were interchanged singly and in various combinations, reconstituted with the starch and water-soluble fraction, and baked into bread. The low- and medium-molecular-weight glutenins of the acid-soluble-gluten proteins controlled mixing time; and the gliadins controlled loaf volume and crumb grain.

GRAIN QUALITY CHARACTERIZATION RESEARCH UNIT

Work of the Grain Quality Characterization Research Unit concerns the development and evaluation of chemical, biochemical, physical and physicochemical methods, and instrumentation for characterizing and determining the quality of cereal grains. The information from these investigations is used to develop methods for evaluating cereal grains in marketing channels and developing, in cooperation with the Agricultural Marketing Service and the Federal Grain Inspection Service, proposals for modifying and improving grain standards and grades. Specifically, researchers conduct basic and applied research on (1) the value and limits of objective tests in the present grain standards and development of methods to simplify, accelerate, and automate those objective tests; (2) methods to replace subjective evaluation in present grain standards by objective, simple, rapid, and automated assays; (3) methods that are not included in the present grain standards but which are needed to fully determine grain quality; (4) physical properties and composition of cereal grains; and (5) development and standardization procedures appropriate for evaluating grain in laboratory and marketing channels. Recent progress in these areas of research is summarized as follows.

Determining Moisture in Wet Grain

To store properly, sometimes grain must be harvested when it is too wet. Although the normal (approximately 14 percent) moisture content of grain can be measured, the results are not reliable if the moisture exceeds 25 percent. A need exists to develop a fast, reliable method for measuring the moisture (up to 40 percent) in wet grain. We have developed calibration curves using a pulsed nuclear

magnetic resonance device for wheat, barley, sorghum, and corn at moisture contents between 15 and 40 percent. We also are evaluating a capacitance moisture meter for measuring the moisture content of corn.

Determining Degree of Milling of Rice

A rapid, objective method was developed to rate the degree of milling of rice. It involves a 5-minute extraction of 10 g of milled rice with 40 ml of isopropyl alcohol-water (1:1, v/v) and measuring the electrical conductivity (micromhos/cm) of the extract. The objective and subjective ratings for the degree of milling of rice were highly correlated, and the correlations of both types of ratings with ash, surface lipid, and agtron color were higher for experimentally than for commercially milled samples. The objective test is sensitive to the percentage of broken kernels in the sample. There are scientific reasons why the objective specific conductance method is better than the subjective rating for measuring the degree of milling of rice. The specific conductance method is rapid, reproducible, can be performed by relatively unskilled personnel, and removes any error in judgment by the subjective method. In general, a method that allows continuous measurement, such as the specific conductance method, is preferable to a discrete rating method such as the subjective rating now employed to measure the degree of milling of rice.

Interlaboratory and Intralaboratory Reproducibility of Protein Determination in Hard Red Wheat by Kjeldahl and Near Infrared Procedures

Protein content was determined in eight samples, three of which were duplicates, of hard red winter (HRW) wheat, 10 to 14 percent protein, by the Kjeldahl method in 24 laboratories and by the near infrared reflectance (NIR) method in 30 laboratories in which Neotec 31 EL or Technicon InfraAlyzer instruments were used. All samples were ground and tested by the NIR method at all 30 laboratories; however, ground samples were returned from only 24 of the 30 laboratories to USGMRL. Ranges in particle size of all returned samples were measured and the variability in protein contents was evaluated by comparisons with data from Kjeldahl and NIR analyses conducted in a single laboratory (USGMRL). Finally, portions of the five different wheat samples were ground at USGMRL to cover the range of particle size that had been measured in the ground samples returned from the 24 laboratories.

The samples were analyzed at USGMRL for protein by the Kjeldahl and NIR methods and for particle size. The standard deviation for Kjeldahl data from Group A laboratories (four government, four university and four commercial) was judged *a priori* to be low; it was, in fact, significantly lower than the standard deviation for comparable data from the 12 Group B laboratories where wheat in trading channels was analyzed. The standard deviations did not differ significantly among the data from Kjeldahl analyses in Group B laboratories and comparable data from analyses by either Neotec 31 EL or Technicon InfraAlyzer NIR instruments. Therefore, the use of the NIR instruments would not reduce the reliability of protein determinations in the marketing of HRW wheat. In the ground samples returned from the 24 collaborating NIR laboratories, average particle size ranged from 110 to 168 μm. No significant effect on either particle size or protein content could be attributed to the use of different Udy cyclone grinders in different laboratories. In samples ground at USGMRL, average particle size ranged from 111 to 162 μm and did not consistently affect protein content as determined by the NIR method. We concluded that the Udy cyclone grinder is suitable for grinding HRW wheat samples to analyze protein content by the NIR method.

Standard Method for Measuring Susceptibility of Shelled Corn to Breakage During Handling

Whole kernel corn without heat damage is desired by foreign buyers and by those who process corn. The increase in broken corn between origin and destination is of particular concern. Therefore, a method which will simply, quickly, and repeatably measure the potential for corn to break up during handling is highly desirable. Such a method would make it possible to reward producers and handlers of quality grain.

Test conditions rarely duplicate those in a real-life situation. However, to approach a normal grain handling operation, a grain acceleration device was built that impacts corn against corn at velocities both above and below that attained by corn falling vertically from a height of 100 feet. Results were compared from the grain acceleration device and the Stein Breakage Tester, Model CK-2. The effect of several variables is now being studied and the procedure is being standardized for operating the Stein Breakage Tester, Model CK-2.

ECONOMICS, STATISTICS, AND COOPERATIVES SERVICE,[1] COMMODITY ECONOMICS DIVISION

Grains and Feeds Program Area

The activity of this unit encompasses the economic evaluation of a wide variety of subjects related to the production and marketing of grain and grain products. General areas of research include grain quality, production costs, storage, marketing and transportation analysis. Special areas of research include assessment of such current issues as dust emission, solar grain drying, and the analysis of data used in making public policy decisions.

Main objectives of these economic evaluations are to (1) provide economic assessments of new technologies and approaches to grain production and marketing such as comparing costs of solar and conventional grain drying systems and estimating costs of pelletizing grain dust; (2) analyze the efficiency of assembling, processing, and distributing grain and grain products; (3) conduct supply-demand analyses; (4) estimate costs of producing and marketing grains and grain products including white pan bread; and (5) provide quick analyses of current topics.

Basic to the research efforts of this group, which is headquartered in Washington, D.C., is the interdisciplinary approach and environment afforded by USGMRL. This unit works in close cooperation with Science and Education Administration, Agricultural Research personnel, as well as with personnel at Kansas State University.

LIST OF PUBLICATIONS

Bechtel, D. B. and Pomeranz, Y. 1977. Ultrastructure of the mature ungerminated rice *(Oryza sativa)* caryopsis. The caryopsis coat and the aleurone cells. American Journal of Botany 64: 966-973.

Bechtel, D. B. and Pomeranz, Y. 1978. Implications of the rice kernel structure in storage, marketing and processing: A review. Journal of Food Science 43: 1538-1542, 1552.

Bechtel, D. B. and Pomeranz, Y. 1978. Ultrastructure of the ungerminated barley caryopsis. (Abstract). Cereal Foods World. 23: 480.

Bechtel, D. B. and Pomeranz, Y. 1978. Ultrastructure of the mature ungerminated rice *(Oryza sativa)* caryopsis. The germ. American Journal of Botany 65: 75-85.

Bechtel, D. B. and Pomeranz, Y. 1977. The making of bread. A light and transmission electron microscope investigation of a dough mixed from various flours. (Abstract). Cereal Foods World 22: 471.

Bechtel, D. B. and Pomeranz, Y. 1978. Ultrastructure of the ungerminated rice *(Oryza sativa)* caryopsis. The starchy endosperm. American Journal of Botany 65: 684-691.

Bechtel, D. B., Pomeranz, Y., and de Francisco, A. 1978. The making of bread. A light and transmission electron microscopic study. Cereal Chemistry 55: 392-401.

Bechtel, D. B., Pomeranz, Y., and de Francisco, A. 1977. The making of bread. A light and transmission electron microscopic study of a fermented dough and baked loaf. (Abstract). Cereal Foods World 22: 471.

Boles, H. P. 1978. Comparative resistance of barley as influenced by source, aleurone layer, and protein levels. (Abstract). North Central Branch ESA Proceedings, Madison, Wis.

Boles, H. P. and Pomeranz, Y. 1978. Protective effects of barley hulls against the rice weevil. Journal of Economic Entomology. In press.

Boles, H. P. and Pomeranz, Y. 1978. Genetic resistance in cereal grains to storage insects. *In* Report of 10th National Conference on Wheat Utilization Research, Tucson, Ariz. In press.

Bulla, L. A., Jr. 1978. Past history and current status of the development of active strains of *Beauveria bassiana* in the United States. Proceedings U.S.-U.S.S.R. Conference on Cultivation and Use of Entomopathogenic Fungi.

Bulla, L. A., Jr. 1978. Bacterial bioinsecticides. *In* J. R. Porter (ed). Under-exploited microbial processes of potential economic value. National Academy of Sciences, Washington, D.C. pp. 153-161.

Bulla, L. A., Jr. 1978. Physiology of sporeforming bacteria associated with insects: enzymatic analysis of the aerobic and anaerobic metabolism of *Bacillus popilliae, Bacillus lentimorbus,* and *Bacillus larvae. In* A. N. Barker, L. J. Wolf,

[1] Formerly the Economic Research Service.

D. J. Eller, G. J. Dring, and G. W. Gould (eds.). Academic Press, New York, N.Y. pp. 407-419.

Bulla, L. A., Jr. and Cheng, T. C. (editors). 1978. Comparative Pathobiology. Vol. 4. Invertebrates as Models for Biomedical Research. Plenum Publishing Corp., New York, N.Y. 353 pp.

Bulla, L. A., Jr. and Yousten, A. A. 1978. Bacterial insecticides. *In* A. H. Rose (ed.). Economic Microbiology. Academic Press, New York. In press.

Bulla, L. A., Jr., Costilow, R. N., and Sharpe, E. S. 1978. Biology of *Bacillus popilliae*. Advances in Applied Microbiology 23: 1-18.

Bulla, L. A., Kramer, K. J., and Speirs, R. D. 1978. Insects and microorganisms in stored grain and their control. *In* Y. Pomeranz (ed.). Advances in Cereal Science and Technology, Vol. II, pp. 91-133, American Association of Cereal Chemists, St. Paul, Minn.

Bulla, L. A., Jr., Shethna, Y. S., Aronson, A. I., and Fitz-James, P. C. 1978. Biology of *Bacillus thuringiensis*. CRC Critical Review in Microbiology. In press.

Chung, K. H. and Pomeranz, Y. 1978. Acid soluble proteins of wheat flours. I. Effect of delipidation on protein extraction. Cereal Chemistry 55: 230-243.

Chung, K. H. and Pomeranz, Y. 1978. Acid soluble proteins of wheat flours. II. Binding to hydrophobic gels. (Abstract). Cereal Foods World 23: 480.

Chung, O. K. 1978. Preface. *In* Symposium Proceedings on Cereal Lipids: What They Are and What They Do. Cereal Chemistry. In press.

Chung, O. K., Pomeranz, Y., and Finney, K. F. 1978. Wheat flour lipids in breadmaking. The Symposium on Cereal Lipids: What They Are and What They Do. Proceedings. Cereal Chemistry. In press.

Chung, O. K., Pomeranz, Y., Finney, K. F., and Shogren, M. D. 1978. Surfactants as replacements for natural lipids in bread baked from defatted wheat flour. Journal of American Oil Chemists Society 55: 635-641.

Chung, O. K., Pomeranz, Y., Finney, K. F., and Shogren, M. D. 1978. Defatted and reconstituted wheat flours. III. Effects of flour moisture content and aqueous binary azeotropes on functional (breadmaking) properties. Cereal Chemistry 55: 31-43.

Chung, O. K., Pomeranz, Y., Hwang, E. C., and Dikeman, E. 1978. Defatted and reconstituted wheat flours. IV. Effects of flour lipids on protein extractability from flours that vary in breadmaking quality. Cereal Chemistry. In press.

Chung, O. K., Pomeranz, Y., Howard, B. G., and others. 1978. Lipids in triticales. (Abstract). Cereal Foods World 23: 464.

Cluskey, J. E., Fellers, D. A., Inglett, G. E. and others. 1978. Cereal proteins from grain processing. *In* M. Milner, N. S. Scrimshaw, D. I. C. Wang (eds.). Protein Resources & Technology. Avi Publishing Company, Westport, Conn. Ch. 16, pp. 256-277.

Converse, H. H., Foster, G. H., and Sauer, D. B. 1978. Low temperature grain drying with solar heat. American Society of Agricultural Engineers Transactions 21: 170-175.

Converse, H. H., Miller, B. S., and Graves, A. H. 1977. Quality changes of hard red winter wheat in concrete silos. Science and Education Administration, Agricultural Research, U.S. Department of Agriculture, ARS-NC-58.

Fan, L. T., Lai, F. S., Akao, Y., and others. 1978. Numerical and experimental simulation studies on the mixing of particulate solids and the synthesis of a mixing system. Computer and Chemical Engineering 2: 19-32.

Fan, L. T., Too, J. R., Lai, F. S., and Akao, Y. 1978. Studies on multicomponent solids mixing and mixtures. I. Estimation of a mixing index from contact number for a homogeneous mixture. Powder Technology. In press.

Finney, K. F. 1978. Contribution of individual chemical constituents to the functional (breadmaking) properties of wheat. Food Technology. In press.

Finney, K. F. 1978. Genetically high protein hard winter wheat. Bakers Digest 52(3): 12-18.

Finney, K. F. and Shogren, M. D. 1978. Mixografo per l'accertamento delle qualita panificabili dell farine su campioni da 10 grammi. Molini d'Italia 29(1): 12-18.

Finney, K. F., Jones, B. L., and Shogren, M. D. 1978. Functional (breadmaking) properties of wheat protein fractions obtained by ultracentrifugation. (Abstract). Cereal Foods World 23: 479.

Finney, K. F., Heyne, E. G., Shogren, M. D., and others. 1978. Functional properties of high-yielding European wheats grown at Manhattan, Kansas. (Abstract). Cereal Foods World 23: 479.

Finney, K. F., Shogren, M. D., Bolte, L. C. and others. 1977. Quality characteristics of hard winter wheat varieties grown in the southern, central, and northern Great Plains of the United States. 1976 Crop, U.S. Department of Agriculture mimeographed publication No. HWWQL-40, December 1977.

Guadagni, D. G., Storey, C. L., and Soderstrom, E. L. 1978. Effect of controlled atmosphere on flavor stability of raisins. Journal of Food Science. In press.

Guadagni, D. G., Soderstrom, E. L., and Storey, C. L. 1978. Effect of controlled atmosphere on flavor stability of almonds. Journal of Food Science 43: 1077-1080.

Heid, W. G., Jr. 1978. The performance and economic feasibility of solar grain drying systems. Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture, Agricultural Economic Report No. 396. 33 pp.

Heid, W. G., Jr. and Leath, M. N. 1978. U.S. Barley Industry Statistics: 1950-76. Commodity Economics Division, Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture. 82 pp.

Heid, W. G., Jr. and Leath, M. N. 1978. U.S. Barley Industry. Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture, Agricultural Economic Report No. 395. 66 pp.

Jacobs, R. M., Kramer, K. J., Speirs, R. D., and Hendricks, L. H. 1978. Effect of vertebrate hypoglycemic and β-cell cytotoxic agents in insects. Comparative Biochemistry and Physiology. In press.

Jones, B. L., Lookhart, G. L., and Finney, K. F. 1978. Physical and biochemical properties of wheat protein fractions obtained by ultracentrifugation. (Abstract). Cereal Foods World 23: 484.

Jones, B. L., Lookhart, G. L., and Mak, A. S. 1978. Use of the S-pyridylethyl derivative for determination of cysteine during protein sequencing. (Abstract.) American Chemical Society, 175th ACS National Meeting, Anaheim, Calif.

Kramer, K. J. 1978. Insulin-like and glucagon-like hormones in insects. *In* Thomas Miller (ed.). Experimental Entomology: Peptide Neurohormones. Springer/Verlag, New York, N.Y. In press.

Kramer, K. J. and McGregor, H. E. 1978. Activity of TH-6041 and TH-6042 against stored product insects. Journal of Economic Entomology. In press.

Kramer, K. J. 1978. Research in biochemistry and the action of insect growth regulators. *In* R. Strong, R. B. Mills, and L. A. Bulla (eds.). Prevention and Control of Insects in Stored Food Products. Kansas State University Press, Manhattan. In press.

Kramer, K. J. and Childs, C. N. 1977. Interaction of juvenile hormone with carrier proteins and hydrolases from insect hemolymph. Insect Biochemistry 7: 397-403.

Kramer, K. J. and McGregor, H. E. 1978. Reproductive inhibition of stored product insects by Mobil 9087. Journal of the Kansas Entomological Society. In press.

Kramer, K. J. and McGregor, H. E. 1978. Activity of pyridyl and phenyl ether analogs of juvenile hormone against Coleoptera and Lepidoptera in stored grain. Journal of Economic Entomology 71: 132-134.

Kramer, K. J., Hendricks, L. H., and Seib, P. A. 1978. Effect of ascorbic acid and three ester conjugates on the tobacco hornworm, *Manduca sexta* Johannson (Lepidoptera: Sphingidae). Journal of Agricultural and Food Chemistry 26: 874-878.

Kramer, K. J., Speirs, R. D., and Childs, C. N. 1978. A method for separation of trehalose from insect hemolymph. Analytical Biochemistry 86: 692-696.

Kramer, K. J., Speirs, R. D., and Childs, C. N. 1977. Immunochemical evidence for a gastrin-like peptide in insect neuroendocrine system. General and Comparative Endocrinology 32: 423-426.

LaHue, D. W. 1978. Pirimiphos-methyl and chlorpyrifos-methyl as controls of indigenous insect infestations in farmers stock peanuts. Journal of Economic Entomology. In press.

LaHue, D. W. and Kadoum, A. 1978. Effectiveness of emulsion and encapsulated formulations of malathion and fenitrothion. Journal of Economic Entomology. In press.

Lai, F. S. 1978. Analyses of variation of fine material and broken kernels in grain. Journal of Agricultural Engineering Research 23: 1-10.

Lai, F. S. and Pomeranz, Y. 1978. Malt processing stability of barley cultivars—a statistical analysis. Journal of Food Quality 1(2): 157-180.

Lookhart, G. L. and Feather, M. S. 1978. Acid-catalyzed isomerization and dehydration of DL-glyceraldehyde and 1,3-dihydroxy-2-propanone. Carbohydrate Research 60: 259-265.

Lookhart, G. L., Jones, B. L., and Finney, K. F. 1978. Determination of coumestrol in soybeans by high performance liquid and thin-layer chromatography. Cereal Foods World 23: 333. (Abstract). Cereal Chemistry. In press.

Martin, C. R. and Lai, F. S. 1978. Measurement of grain dustiness. Cereal Chemistry. In press.

Mathewson, P. R. and Pomeranz, Y. 1978. A modified chromogenic alpha-amylase assay for sprouted wheat. Journal of the Association of Official Analytical Chemists. In press.

Mathewson, P. R. and Pomeranz, Y. 1978. On the relationship between alpha amylase and the falling number in wheat. Journal of Food Science 43: 652-653.

Mathewson, P. R. and Pomeranz, Y. 1978. Hot-paste viscosity and alpha-amylase susceptibility of hard red winter wheat flour. Journal of Food Science 43: 60-63.

Mathewson, P. R., Rousser, R., and Pomeranz, Y. 1978. A compact, self-contained unit for assay of alpha-amylase. (Abstract). Cereal Foods World 23: 493.

Mathewson, P. R., Rousser, R., and Pomeranz, Y. 1978. A compact, self-contained unit for assay of alpha-amylase. Cereal Foods World. In press.

McGaughey, W. H. 1978. Response of *Plodia interpunctella* and *Cadra cautella* larvae to spores and parasporal crystals of *Bacillus thuringiensis*. Journal of Economic Entomology. In press.

McGaughey, W. H. 1978. Moth control in stored grain: efficacy of *Bacillus thuringiensis* on corn and method of evaluation using small bins. Journal of Economic Entomology. In press.

McGaughey, W. H. 1978. Effect of larval age on the susceptibility of almond moths and Indian meal moths to *Bacillus thuringiensis*. Journal of Economic Entomology. In press.

McGaughey, W. H. and Kinsinger, R. A. 1978. Susceptibility of angoumois grain moths to *Bacillus thuringiensis*. Journal of Economic Entomology 71: 435-536.

McGaughey, W. H., Dicke, E. B., and Schesser, J. H. 1978. Indian meal moth infestation of farm-stored wheat in Kansas. Journal of Economic Entomology 71: 503-506.

Miller, B. S. 1978. Grain dust research at the U.S. Grain Marketing Research Laboratory. Cereal Foods World 23: 403-407.

Miller, B. S., Pomeranz, Y., Thompson, W. O. and others. 1978. Interlaboratory and intralaboratory reproducibility of protein determination in hard red winter wheat by Kjeldahl and near infrared procedures. Cereal Foods World 23: 198-201.

Mills, R. B. and Storey, C. L. 1978. Insect infestation at the Combine Grain Harvesting Symposium-Proceedings, International Grain and Forage Harvesting Conference. American Society of Agricultural Engineers. pp. 79-80.

Nickerson, K. W. and Bulla, L. A., Jr. 1978. Incorporation of specific fatty acid precursors during spore germination and outgrowth of *Bacillus thuringiensis*. Journal of Bacteriology. In press.

Niernberger, F. F. 1978. Near-infrared reflectance instrument analysis of grain constituents: a cost study. Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture, ESCS-20. 19 pp.

Niernberger, F. F. 1978. Instruments for rapid protein determination for wheat may change wheat marketing strategies for Kansas producers. Wheat Marketing Field Day for Kansas Wheat Producers Proceedings. Report of Progress 323. Kansas Agricultural Experiment Station, Manhattan.

Niernberger, F. F., Eustace, W. D., and Ward, A. B. 1977. Economic models of flour mills. Part III—Equipment and equipment costs. Association of Operative Millers Bulletin, November-December 1977. pp. 3690-3699.

Pomeranz, Y. 1978. Barley. *In* N. W. Desrosier (ed.). Elements of Food Technology. Avi Publishing Company, Westport, Conn. pp. 173-176.

Pomeranz, Y. 1978. Malt and malting. *In* N. W. Desrosier (ed.). Elements of Food Technology. Avi Publishing Company, Westport, Conn. pp. 176-178.

Pomeranz, Y. (editor). 1978. Advances in Cereal Science and Technology. Vol. II. American Association of Cereal Chemists, St. Paul, Minn.

Pomeranz, Y. 1978. Wheat in China. Advances in Cereal Science and Technology. Vol. II. pp. 387-413.

Pomeranz, Y. 1978. Analytical techniques used in the food sciences. Encyclopedia of Food Science. *In* M. S. Peterson and A. H. Johnson (editors). Avi Publishing Company, Westport, Conn. pp. 28-34.

Pomeranz, Y. 1978. Cereal foods in the People's Republic of China. 1977 Corn Quality Conference, Department of Agricultural Economics Proceedings, University of Illinois, Urbana. AE-4454. pp. 207-210.

Pomeranz, Y. (editor). 1978. Cereals '78: Better Nutrition for the World's Millions. American Association of Cereal Chemists, St. Paul, Minn.

Pomeranz, Y. (editor). 1978. Wheat chemistry and technology (2nd edition). American Association of Cereal Chemists, St. Paul, Minn.

Pomeranz, Y. 1978. Rice. International Union of Food Science Technology. Annual Report. Spain. In press.

Pomeranz, Y. 1978. Problems in baking (amyloglucosidase and lactose). Bakers Digest 52(1): 52.

Pomeranz, Y. and Bechtel, D. B. 1978. Structure of cereal grains as related to end-use properties. *In* Cereals '78: Better Nutrition for the World's Millions. American Association of Cereal Chemists, St. Paul, Minn. pp. 75-84.

Pomeranz, Y. and Bechtel, D. B. 1978. Structure of cereal grains as related to end-use properties. Basic symposium—postharvest biology and technology proceedings. Institute of Food Technologists, Philadelphia, Pa. In press.

Pomeranz, Y. and Chung, O. K. 1978. Interaction of lipids with proteins and carbohydrates in breadmaking. Journal of the American Oil Chemists Society 55: 285-289.

Pomeranz, Y. and Chung, O. K. 1978. Starch-lipid-protein interaction in cereals. International Symposium on Protein Utilization Proceedings, Guleph, Canada. In press.

Pomeranz, Y. and Meloan, C. E. 1978. Food analysis: theory and practice. Revised. Avi Publishing Company, Westport, Conn.

Quinlan, J. K. 1978. The effectiveness of chlorpyrifos-methyl and malathion as protectants for high moisture stored wheat. Journal of Economic Entomology. In press.

Quinlan, J. K., Bulla, L. A., Jr., and Gray, H. 1978. Guidelines for evaluating the efficacy of chemical insecticides as protectants of stored grain against insect pests—a modification. *In* L. A. Bulla, Jr., R. B. Mills, J. R. Pederson, and R. G. Strong (eds.). Symposium on Prevention and Control in Stored-Food Products Proceedings. Kansas State University, Manhattan.

Regier, J. C., Kafatos, F. C., Kramer, K. J., and others. 1978. Silkmoth chorion proteins: general characterization of a protein family, purification methods and amino terminal sequence of one component. Journal of Biological Chemistry 253: 1305-1314.

Rousser, R. and Finney, K. F. 1978. Note on construction of efficient and safe crucible trays and tongs for muffle furnaces. Cereal Chemistry 55: 521-523.

Sauer, D. B. 1978. Contamination by mycotoxins: when it occurs and how to prevent it. *In* T. D. Wyllie and L. G. Morehouse (eds.). Mycotoxic Fungi, Mycotoxins, Mycotoxicoses, an Encyclopedic Handbook, Vol. 3. Marcel Dekker, Inc., New York, N.Y.

Sauer, D. B., Seitz, L. M., Burroughs, R., and others. 1978. Toxicity of *Altenaria* metabolites found in weathered sorghum grain at harvest. Journal of Agricultural and Food Chemistry. In press.

Schesser, J. H. and Bulla, L. A., Jr. 1978. Toxicity of *Bacillus thuringiensis* spores to the tobacco hornworm, *Manduca sexta*. Applied Environmental Microbiology 35: 121-123.

Schesser, J. H. and Bulla, L. A., Jr. 1978. Susceptibility of Indian meal moth, *Plodia interpunctella* to *Bacillus thuringiensis* parasporal crystals. Applied Environmental Microbiology. In press.

Schnake, L. D. and Driscoll, J. L. 1978. Number and physical characteristics of grain elevators. Economics, Statistics, and Cooperative Services, U.S. Department of Agriculture, ESCS-22. 35 pp.

Schnake, L. D. and Leath, M. N. 1978. Factors affecting family expenditures for cereals and bakery products. Wheat Situation, WS-245, pp. 14-17.

Seitz, L. M., Mohr, H. E., Burroughs, R., and Sauer, D. B. 1978. Ergosterol as an indicator of fungal invasion in grains. Cereal Chemistry 54: 1207-1217.

Seitz, L. M., Sauer, D. B., Mohr, H. E. and others. 1978. Aspergillus growth on grain measured by ergosterol, chitin and aflatoxin assays. (Abstract). Cereal Foods World 23: 491.

Sharpe, E. S. and Bulla, L. A., Jr. 1978. Characteristics of the constituent substrains of *Bacillus popilliae* growing in batch and continuous cultures. Applied and Environmental Microbiology 35: 601-609.

Shogren, M. D., Pomeranz, Y., and Finney, K. F. 1978. Hydrolyzed lactose in bread for lactose-intolerant consumers. (Abstract). Cereal Foods World 23: 422.

Speirs, R. D. and Kramer, K. J. 1978. Some morphological effects of diabetogenic agents in insects. (Abstract). Journal of the Kansas Entomological Society 51: 400.

St. Julian, G., Bulla, L. A., Jr., and Detroy, R. W. 1978. Longevity of *Bacillus popilliae* spores and their infectivity against *Popillin japonica* larvae. Journal of Invertebrate Pathology. In press.

Stahly, D. P., Dingman, D. W., Bulla, L. A., Jr., and Aronson, A. I. 1978. Possible origin and function of the parasporal crystals in *Bacillus thuringiensis*. Biochemical and Biophysical Research Communications. In press.

Storey, C. L. 1978. Mortality of cowpea weevil in a low-oxygen atmosphere. Journal of Economic Entomology. In press.

Storey, C. L. 1978. Inert atmosphere for control of insects in stored commodities. Intercontinental Publications Inc., Modern Government/National Development. In press.

Storey, C. L. and Bulla, L. A., Jr. 1978. Controlling insect pests in stored grain. International Edition, Farm Chemicals. In press.

Storey, C. L. and Hatchett, J. H. 1978. Phosphine fumigation for possible Hessian fly contamination of United States hay exports to Japan. Technical Report to Japanese Ministry of Agriculture and Forestry, Plant Quarantine Division, Manhattan, Kan.

Storey, C. L. and Sauer, D. B. 1978. Progress report: 1977 Survey of insect and microbial activity in United States wheat and corn exports. Technical report to U.S. Department of Agriculture, Federal Grain Inspection Service, Standardization Division, Manhattan, Kan.

Tanaka, Y., Resurreccion, A. P., Juliano, B. O., and Bechtel, D. B. 1978. Properties of whole and undigested fraction of protein bodies of milled rice. Agricultural and Biological Chemistry. In press.

Tweeten, K. A., Bulla, L. A., Jr., and Consigli, R. A. 1978. Characterization of an alkaline protease associated with a granulosis virus of *Plodia interpunctella*. Journal of Virology 26: 702-711.

Tweeten, K. A., Bulla, L. A., Jr., and Consigli, R. A. 1977. Supercoiled circular DNA of an insect granulosis virus. National Academy of Science Proceedings 74: 3574-3578.

Tweeten, K. A., Bulla, L. A., Jr., and Consigli, R. A. 1978. Isolation and purification of a granulosis virus from infected larvae of the Indian meal both, *Plodia interpunctella*. Applied Environmental Microbiology 34: 320-327.

Tweeten, T. N., Wetzel, D. L., and Chung, O. K. 1978. High performance liquid chromatography of polar fractions of wheat flour lipids. II. Characterization of components in the chromatographic separation. (Abstract). Cereal Foods World 23: 486.

Wilbur, D. A., Mills, R. B., and Boles, H. P. 1978. Food infesting pests. Section 8: National Pest Control Association Encyclopedia of Pest Control. In press.

INVITATIONAL PAPERS, TECHNICAL PRESENTATIONS, AND OTHER REPORTS

Bechtel, D. B. and Pomeranz, Y. October 23, 1977. The making of bread. A light and transmission electron microscopic investigation of a dough mixed from various flours. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Bechtel, D. B., Pomeranz, Y., and deCasas, A. F. October 23, 1977. The making of bread. A light and transmission electron microscopic study of a fermented dough and baked bread. 62nd Annual Meeting, American Association of Cereal Chemists, San Francisco, Calif.

Chung, K. H. and Pomeranz, Y. October 23, 1977. Acid-soluble proteins of wheat flours. I. Effect of delipidation on protein solubility. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Chung, O. K., Pomeranz, Y., and Hwang, E. C. October 23, 1977. Defatted and reconstituted wheat flours. IV. Effects of flour lipids on pro-

tein extractability of flours varying in breadmaking quality. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Chung, O. K., Pomeranz, Y., Shogren, M. D., and others. October 23, 1977. Defatted and reconstituted wheat flours. V. Shortening responses in flours varying in breadmaking quality. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Chung, O. K., Pomeranz, Y., Finney, K. F., and Shogren, M. D. October 23, 1977. Defatted and reconstituted wheat flours. VI. Responses to shortening in flour differentially defatted by solvents at various temperatures. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Mathewson, P. R. and Pomeranz, Y. October 23, 1977. Detection of sprouted wheat by a simple, sensitive, and versatile method. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Miller, B. S., Pomeranz, Y., Thompson, W. O., and others. October 23, 1977. Inter- and ultralaboratory reproducibility of protein determination by Kjeldahl and near infrared procedures in hard red winter wheat. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Pomeranz, Y., Davis, G. D., Stoops, J. L., and Hubbard, J. D. October 23, 1977. Estimation of protein content and quality in sorghum. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Pomeranz, Y., Davis, G. D., Stoops, J. L., and others. October 23, 1977. Estimation of protein content and quality in maize. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Tweeten, T. N., Wetzel, D. L., and Chung, O. K. October 23, 1977. Analytical HPLC of glycolipid fractions of wheat flour. 62nd Annual Meeting American Association of Cereal Chemists, San Francisco, Calif.

Pomeranz, Y. October 28, 1977. Molecular approach to breadmaking. Interdepartmental seminar. Oregon State University, Corvallis.

Pomeranz, Y. October 31, 1977. Methods for determination of sprout damage. Washington State University, Pullman.

McGaughey, W. H. November 1, 1977. Summary of progress on evaluating the efficacy of *Bacillus thuringiensis* for moth control in stored grain. Science and Education Administration, U.S. Department of Agriculture, Insect Pathology Workshop, Brownsville, Tex.

Sauer, D. B. November 3, 1977. Epidemiology of *Aspergillus flavus* in corn. Seminar presented at Kansas State University, Department of Plant Pathology, Manhattan.

Kramer, K. J. November 10, 1977. Chemical and post-translational modifications of proteins. Department of Biochemistry, Kansas State University, Manhattan.

Boles, H. P. and Pomeranz, Y. November 17, 1977. Genetic resistance in cereal grains to storage insects. 10th National Conference Wheat Utilization Research, Tucson, Ariz.

Demopolous-Rodriguez, J. T., Loesch, P. J., Jr., Wiser, W. J., and Pomeranz, Y. November 18, 1977. Inheritance of protein content and quality in a synthetic population of opaque-2 maize. 69th Annual Meeting Crop Science Society of America, Los Angeles, Calif.

Dziadik, C. and Kramer, K. J. November 19, 1977. Insect chitinolytic enzymes. Purification and characterization of N-butyl-β-D-glucosaminases. 20th West Central States Biochemical Conference, Manhattan, Kans.

Pomeranz, Y. November 21, 1977. Observation of agriculture in Russia and Mainland China. 1977 Corn Quality Research Conference, Champaign, Ill.

Boles, H. P. November 27, 1977. Effects of wheat grain hardness and bran coat removal on rice weevil development. Entomological Society of America Annual Meeting, Washington, D.C.

Pomeranz, Y. November 30, 1977. How to feed a billion people. Department of Foods and Nutrition, Kansas State University, Manhattan.

Kramer, K. J. December 6, 1977. Hormonal control of carbohydrate metabolism in insects. Entomological Society of America National Meeting, Washington, D.C.

Pomeranz, Y. December 10, 1977. Objective measurement of damaged wheat. Pioneer Section, American Association of Cereal Chemists Meeting, Wichita, Kans.

Converse, H. H. December 13, 1977. Drying and storing harvested grain. Steel Products Clinic, Farmland Industries, Inc., Hutchinson, Kans.

Pomeranz, Y. December 15, 1977. The U.S. Grain Marketing Research Laboratory, American Association of Cereal Chemists Meeting, Kansas Section, Manhattan.

Finney, K. F. January 27, 1978. Genetically high protein hard winter wheat. Hard Winter Wheat Quality Council Annual Meeting, Manhattan, Kans.

Pomeranz, Y. February 6, 1978. How to feed a billion people. Farmers Elevator Association of Minnesota, Minneapolis.

Bulla, L. A., Jr. and Bechtel, D. B. February 26, 1978. Synthesis of membrane fatty acids during growth and sporulation of *Bacillus thuringiensis*. American Society for Microbiology Conference on Microbial Membranes, Charleston, S.C.

Pomeranz, Y. March 1, 1978. Review of work on high protein wheat at the U.S. Grain Marketing Research Center. American Bakers Association Technical Liaison Committee Meeting, U.S. Department of Agriculture, Western Regional Research Center, Albany, Calif.

Chung, O. K. March 2, 1978. Advanced Cereal Chemistry Class, Department of Grain Science and Industry, Kansas State University, Manhattan.

(a) Lipids in grains: Their composition (methods of extraction purification, and identification).
(b) Wheat flour lipids: What they do.
(c) Interaction of wheat flour lipids with proteins and carbohydrates in breadmaking.

Finney, K. F. March 10, 1978. Quality of Kansas wheat varieties. 6th Annual Wheat Marketing Field Day, Russell, Kans.

Niernberger, F. F. March 10, 1978. Instruments for rapid protein determination for wheat may change wheat marketing strategies for Kansas wheat producers. Wheat Marketing Field Day for Kansas Wheat Producers Proceedings. Report of Progress 323. Kansas Agricultural Experiment Station, Manhattan.

Pomeranz, Y. March 14, 1978. How to feed a billion people. University of Missouri, Columbia.

Jones, B. L., Lookhart, G. L., and Mak, A. S. March 16, 1978. Use of the S-pyridylethyl derivative for determination of cysteine during protein sequencing. 175th National Meeting American Chemical Society, Anaheim, Calif.

Lookhart, G. L., Jones, B. L., and Finney, K. F. March 16, 1978. The determination of coumestrol in soybean extracts by high performance and thin-layer chromatography. 175th National Meeting American Chemical Society, Anaheim, Calif.

Pomeranz, Y. March 20, 1978. How to feed a billion people. Joint American Association of Cereal Chemists-Institute of Food Technologists, Meeting, Kansas City, Mo.

Finney, K. F. March 23, 1978. Contribution of individual chemical constituents to the functional (breadmaking) properties of wheat. Seminar on Wheat Consumer Needs, New Delhi, India.

Finney, K. F. March 27, 1978. Hard winter wheat quality and research. Institute of Catering Technology and Hotel Management, Pusa, New Delhi, India.

Finney, K. F. March 30, 1978. Genetically high protein hard winter wheat. Seminar on Wheat Consumer Needs, New Delhi, India.

Pomeranz, Y. March 30, 1978. USDA Research Programs on Explosions and Dust. 82nd Annual Meeting and Convention, National Grain and Feed Association, Phoenix, Ariz.

Bechtel, D. B. and Bulla, L. A., Jr. March 31, 1978. Fine structure of forespore formation in *Bacillus thuringiensis*. Annual Meeting, Missouri Valley Branch of the American Society for Microbiology, Wichita, Kans.

Tweeten, K. A., Bulla, L. A., Jr., and Consigli, R. A. March 31, 1978. Structural polypeptides of the granulosis virus of the Indian meal moth, *Plodia interpunctella*. Annual Meeting, Missouri Valley Branch of the American Society for Microbiology, Wichita, Kans.

Finney, K. F. April 3, 1978. Wheat quality studies at the Hard Winter Wheat Quality Laboratory, Central Food Technological Research Institute, Mysore, India.

Lai, F. S., Wang, R. H., and Fan, L. T. April 3, 1978. Use of pattern recognition techniques for classification of solids mixtures and identification of grain samples. 8th Annual Automatic Imagery Pattern Recognition Symposium, National Bureau of Standards, Gaithersburg, Md.

Finney, K. F. April 4, 1978. Short-time sugar-free formulas for making nutritious high protein breads. Central Food Technological Research Institute, Mysore, India.

Kinsinger, R. A. and McGaughey, W. H. April 5, 1978. A white mutation of the almond moth. North Central Branch Entomological Society of America, Madison, Wis.

Quinlan, J. K. April 5, 1978. Chlorpyrifos-methyl and malathion applied as protectants for high moisture stored wheat. North Central Branch Entomological Society of America, Madison, Wis.

Finney, K. F. April 6, 1978. Functional properties of bread wheats and short-time, sugar-free formulas for making nutritious high protein breads. Cummings Laboratory, Pusa, New Delhi, India.

Storey, C. L. April 6, 1978. Phosphine fumigation of U.S. hay exports to Japan. Technical meeting with Japanese Ministry of Agriculture and Forestry, Plant Quarantine Division, Tokyo, Japan.

Converse, H. H. April 8, 1978. Update on solar grain drying. Mid-Central Region Meeting American Society of Agricultural Engineers, St. Joseph, Mo.

Kramer, K. J. April 9, 1978. Research in biochemistry and the action of insect growth regulators. Symposium on Prevention and Control of Insects in Stored-Food Products, Kansas State University, Manhattan.

McGaughey, W. H. April 9, 1978. The AIBS reports on guidelines for efficacy data. Symposium on Prevention and Control of Insects in Stored-Food Products, Kansas State University, Manhattan.

Quinlan, J. K. April 9, 1978. Guidelines for obtaining data on protective materials. Symposium on Prevention and Control of Insects in Stored-Food Products, Kansas State University, Manhattan.

Finney, K. F. April 10, 1978. Functional properties of hard winter wheats with emphasis on genetically high protein content. Japan Grain Research Council and Japan Section of the American Association of Cereal Chemists, Tokyo, Japan.

Finney, K. F. April 12, 1978. Functional (milling and breadmaking) properties of hard winter wheats; and short-time, sugar-free formulas for making regular and high protein breads. Japan Institute of Baking, Tokyo, Japan.

Pomeranz, Y. April 12, 1978. Grain quality standards. Symposium on Prevention and Control of Insects in Stored-Food Products, Kansas State University, Manhattan.

Pomeranz, Y. April 14, 1978. Research activities of the U.S. Grain Marketing Research Laboratory. Kansas Committee of Agricultural Agencies, Manhattan.

Sauer, D. B. April 14, 1978. Export grain survey. Radio interview on Station KSAC, Manhattan, Kans.

Pomeranz, Y. April 19, 1978. American Association of Cereal Chemists Short Course, Minneapolis, Minn.
(a) Chemical composition and kernel structure
(b) Dough functionality and breadmaking

Bulla, L. A., Jr. April 24, 1978. Microbial insecticides. Department of Food Science, North Carolina State University, Raleigh.

Speirs, R. D. and Kramer, K. J. April 25, 1978. Some morphological effects of diabetogenic agents in insects. Central States Entomological Society Meeting, Manhattan, Kans.

Bulla, L. A., Jr. April 26, 1978. Biochemistry and physiology of *Bacillus thuringiensis*. Department of Microbiology, University of Massachusetts, Amherst.

Kinsinger, R. A. and McGaughey, W. H. April 28, 1978. Susceptibility of populations of the Indian meal moth and the almond moth to nine *Bacillus thuringiensis* isolates. Kansas Entomological Society, Manhattan.

Aldis, D. F., Burroughs, R., and Hughes, J. W. May 2, 1978. Solar regeneration of silica gel and use in grain drying. Solar Grain Drying Conference, Purdue University, West Lafayette, Ind.

Pomeranz, Y. May 11, 1978. Colorado State University, Ft. Collins.
(a) Composition, structure and end-use properties of cereal grains.
(b) Life and agriculture in the People's Republic of China.

Bulla, L. A., Jr. May 14, 1978. Convenor of sessions on decontamination and sterilization. American Society for Microbiology Annual Meeting, Las Vegas, Nev.

Kramer, K. J., Bulla, L. A., Jr., Davidson, L. I., and others. May 14, 1978. Solubilization and characterization of the entomocidal glycoprotein of *Bacillus thuringiensis*. American Society for Microbiology National Meeting, Las Vegas, Nev.

Tweeten, K. A., Bulla, L. A., Jr., and Consigli, R. A. May 14, 1978. Structural polypeptides of purified granulosis virus. American Society for Microbiology Annual Meeting, Las Vegas, Nev.

Storey, C. L. May 16, 1978. Insect development and contamination in transported commodities. Chicago Terminal Committee Freight Claim and Damage Prevention Meeting, Chicago, Ill.

Bulla, L. A., Jr. May 22, 1978. Co-convenor of session on evaluation of the efficacy of entomopathogenic fungi against aphids. U.S.-U.S.S.R. Conference on Possibility of Production and Use of Entomopathogenic Fungi, Riga, Latvia, SSR.

Bulla, L. A., Jr., Lingz, A. J., and Grula, E. A. May 22, 1978. Past history and current status of the development of active strains of *Beauveria bassiana* in the United States. U.S.-U.S.S.R. Conference on Possibility of Production and Use of Entomopathogenic Fungi, Riga, Latvia, SSR.

Roche, T. E., Kramer, K. J., and Tempero, L. B. June 4, 1978. Interconversion of the pyruvate dehydrogenase complex from insect fat body. American Society of Biological Chemists National Meeting, Atlanta, Ga.

Martin, C. R. June 28, 1978. Characterization of grain dust properties. American Society of Agricultural Engineers Summer Meeting, Utah State University, Logan.

Seitz, L. M. July 7, 1978. Fungal metabolites and growth in solid substrate fermentations. Gordon Research Conference-Fungal Metabolites: Biogenesis and Function, Plymouth, N.H.

Quinlan, J. K. August 6, 1978. Effectiveness of three candidate grain protectants compared with malathion. 48th Annual Rocky Mountain Conference of Entomology, Gould, Colo.

Boles, H. P. August 7, 1978. Stored grain insects. 48th Annual Rocky Mountain Conference of Entomology, Gould, Colo.

Heid, W. G., Jr. August 8, 1978. Drying grain with solar energy—does it show promise? Annual meeting, AAEA-CAES, Virginia Polytechnic Institute and State University, Blacksburg.

Pomeranz, Y. and Chung, O. K. August 13, 1978. Starch-lipid-protein interaction in cereals. International Symposium on Protein Utilization, University of Guelph, Ontario, Canada.

McGaughey, W. H. September 6, 1978. *Bacillus thuringiensis* for insect control: progress with stored-product insects. 2d International Workshop on *Bacillus thuringiensis*. Darmstadt, Germany.

McGaughey, W. H. September 6, 1978. Spectrum of activity of *Bacillus thuringiensis* isolates: stored-product insects. 2d International Workshop on *Bacillus thuringiensis*, Darmstadt, Germany.

Miller, B. S. September 14, 1978. Research on grain dust conducted at or coordinated by the U.S. Grain Marketing Research Laboratory. Rotary Club, Manhattan, Kans.

Bechtel, D. B. and Pomeranz, Y. September 16, 1978. Ultrastructure of the mature ungerminated barley caryopsis. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Chung, O. K., Pomeranz, Y., Howard, B. G., and others. September 16, 1978. Lipids in triticales. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Finney, K. F., Heyne, E. G., Shogren, M. D., and others. September 16, 1978. Functional properties of high-yielding European wheats grown at Manhattan, Kansas. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Finney, K. F., Jones, B. L., and Shogren, M. D. September 16, 1978. Functional (breadmaking) properties of wheat protein fractions obtained by ultracentrifugation. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Jones, B. L., Lookhart, G. L., and Finney, K. F. September 16, 1978. Physical and biochemical properties of wheat protein fractions obtained by ultracentrifugation. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Lai, F. S. and Pomeranz, Y. September 16, 1978. Nondestructive testing methods. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Mathewson, P. R., Rousser, R., and Pomeranz, Y. September 16, 1978. A compact, self-contained unit for assay of alpha-amylase. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Pomeranz, Y. September 16, 1978. Cereals '78: Better Nutrition for the World's Millions. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Seitz, L. M., Sauer, D. B., Mohr, H. E., and others. September 16, 1978. *Aspergillus* growth on grain measured by ergosterol, chitin and aflatoxin assays. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Shogren, M. D., Pomeranz, Y., and Finney, K. F. September 16, 1978. Hydrolyzed lactose in bread for lactose intolerant consumers. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Tweeten, T. N., Wetzel, D. L., and Chung, O. K. September 16, 1978. High performance liquid chromatography of polar fractions of wheat flour lipids. II. Characterization of components in the chromatographic separation. Sixth International Cereal and Bread Congress, Winnipeg, Canada.

Miller, B. S. September 19, 1978. A feasibility study on use of near infrared (NIR) techniques in examination and characterization of cereal grains and cereal products. American Association of Cereal Chemists Annual Meeting, Winnipeg, Canada.

Miller, B.S. September 20, 1978. Report of the Amylase Methods Technical Committee. American Association of Cereal Chemists Annual Meeting, Winnipeg, Canada.

Miller, B. S., Lee, M. S., Pomeranz, Y., and Rousser, R. September 21, 1978. A rapid, objective method to measure the degree of milling of rice. American Association of Cereal Chemists Annual Meeting, Winnipeg, Canada.

SEMINARS PRESENTED AT THE U.S. GRAIN MARKETING RESEARCH LABORATORY

Bakker-Arkema, F. W. April 13, 1978. High temperature drying of wheat. Department of Agriculture and Engineering, Michigan State University, East Lansing.

Bates, L. S. March 29, 1978. Intergeneric cereal hybrids: milestones and promises in the search for improved nutritional quality. Department of Grain Science and Industry, Kansas State University, Manhattan.

Bechtel, D. B. March 1, 1978. Electron microscopy in research at the U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

Blanshard, J. M. V. October 19, 1977. Pulsed N.M.R. studies of water in bread and its content. Department of Applied Biochemistry and Nutrition, School of Agriculture, University of Nottingham, England.

Erwin, W. May 25, 1978. Fourier transform infrared spectroscopy; its theory and applications. Digilab, Inc., Cambridge, Mass.

Fujino, Y. November 8, 1977. Chemical nature of lipids in rice. Department of Agricultural Chemistry, Obihiro Chikusan University, Obihiro, Hokkaido, Japan.

Heyne, E. G. April 26, 1978. Developing premium wheats. Department of Agronomy, Kansas State University, Manhattan.

Kaczkowski, J. October 12, 1977. Some structural properties of wheat gluten proteins and their heredity in F_1 generation. Biochemistry Department, University of Agriculture, Warsaw, Poland.

Lai, F. S. February 15, 1978. A visit of Japanese university and industries. U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

LeMunyon, F. May 10, 1978. Recent advances in gas chromatography-mass spectroscopy. Midwestern Regional Manager, Finnigan Corporation, Kansas City, Mo.

Morrison, W. R. September 27, 1978. Wheat lipids. Department of Food Science and Nutrition, Glasgow, Scotland.

Reeck, G. R. January 18, 1978. Isolation and characterization of trypsin inhibitor. Department of Biochemistry, Kansas State University, Manhattan.

Ryu, Insoo. April 28, 1978. Green revolution in Korea. Chief Quality Research Division, Wheat and Barley Institute, Office of Rural Development, Ministry of Agriculture and Fishery, Suewon, Korea.

Shethna, Y. I. May 24, 1978. Biochemistry and biological activities of the *Bacillus thuringiensis* parasporal crystal. Microbiology and Cell Biology Laboratory, Indian Institute of Science, Bangalore, India.

Summers, M. D. February 23, 1978. Biological properties of baculoviruses. Department of Entomology, Texas A&M University, College Station.

Wetzel, D. L. February 1, 1978. Spectroscopic cellulose determinations as criterion of flour purity with respect to bran. Department of Biochemistry, Kansas State University, Manhattan.

VISITORS TO THE U.S. GRAIN MARKETING RESEARCH LABORATORY

Many hundreds of visitors to the U.S. Grain Marketing Research Laboratory came from 36 U.S. States and from 58 countries throughtout the world. It is impossible in the short space available to list all the distinguished visitors.

We would, therefore, like to acknowledge here major groups that came at the request of several sponsoring organizations. The Kansas Wheat Commission (in cooperation with Great Plains Inc., Western Wheat Association, Inc., and Foreign Agricultural Service, USDA) sponsored wheat teams from Bolivia, Egypt, India, Iran, Japan, Morocco, the Philippines, Singapore, Sri Lanka, Thailand, and West Germany.

Eight large groups of participants in short courses organized by the American Institute of Baking visited our facilities. Kansas State University sponsored six group-visits by students in agronomy, biology, engineering, and crop science, as part of their training. In addition, we were visited by groups of farmers from Australia, Canada, France, and Israel; members of the NCR-89 committee; members of the Nebraska Wheat Commission; Kansas Committee of Agricultural Agencies; members of the Japanese short course on milling; the Sahel Storage group; members of the 18-nation Agency for International Development—Kansas State University grain marketing short course; members of the Kansas Farm Bureau-foreign representatives group; Western Europe-Unistock team; members of the team from the People's Republic of China; and the post-Congress (Sixth International Cereal and Bread) tour of cereal chemists.

And, last, but certainly not least, we were visited by many groups representing the general public—clubs, schools, colleges, and companies. The frequent, and to the best of our knowledge, only complaint was in the form of a regret that not enough time was scheduled for a more detailed and thorough visit.

STAFF

Administration

Dr. Yeshajahu Pomeranz ..... Director and location leader
Thelma L. Woellhof ..... Secretary-stenographer
Denise I. Dalley ..... Clerk-typist
Albert J. Gehrt ..... Administrative officer
Diane Nickel ..... Purchasing agent
Anita G. Case ..... Clerk-typist
Barbara Marn ..... Clerk-typist
Robert Fitzpatrick ..... Administrative technician

Grain Structure and Composition Unit

Dr. Yeshajahu Pomeranz ..... Research leader and research chemist
Donald B. Bechtel ..... Research chemist
Dr. Okkyung Kim Chung ..... Research chemist
Paul R. Mathewson ..... Chemist
Dr. Larry M. Seitz ..... Research chemist
Darcy Traylor ..... Physical science technician
Harold E. Mohr ..... Physical science technician
Robert Rousser ..... Engineering technician
Thelma L. Woellhof ..... Secretary-stenographer
*Bonnie Howard ..... Research assistant
*Charles Fahrenholz III ..... Research assistant
*Earline Dikeman ..... Research assistant
*Robert Birchard ..... Research assistant

Biological Research Unit

Dr. Lee A. Bulla, Jr. ..... Research leader and microbiologist
Dr. Hobart P. Boles ..... Research entomologist
Dr. Karl J. Kramer ..... Research chemist
Delmon W. LaHue (deceased) ..... Research entomologist
Dr. William H. McGaughey ..... Research entomologist
Harrison E. McGregor ..... Research entomologist
James K. Quinlan ..... Research entomologist
Dr. David B. Sauer ..... Research plant pathologist
John H. Schesser ..... Research entomologist
Roy D. Speirs ..... Research entomologist
Charles L. Storey ..... Research entomologist
Warren E. Blodgett ..... Agricultural research technician
Loren I. Davidson ..... Physical science technician
Edwin B. Dicke ..... Agricultural research technician
Ralph L. Ernst ..... Biological laboratory technician
Barbara Campbell ..... Biological laboratory technician
Leon H. Hendricks ..... Agricultural research technician
Joseph L. Wilson ..... Biological technician
Aileen L. Berroth ..... Clerk-stenographer
*Cindy Childs ..... Research assistant
*Carol A. Dziadik ..... Graduate research assistant
*Elizabeth Cauthorn ..... Research assistant
*Robert Kinsinger ..... Graduate research assistant
*Dana Jo Tyrell ..... Graduate research assistant
*Kim Osbourne ..... Research assistant
Dr. Yogendra I. Shethna ..... Visiting scientist
Indian Institute of Science
Bangalore, India
Dr. Nouralddin Shayesteh ..... Visiting scientist
Rezaiyeh University
Rezaiyeh, Iran

Engineering Research Unit

Dr. Byron S. Miller ..... Acting research leader and research chemist
Dr. Cheng S. Chang ..... Agricultural engineer
Harry H. Converse ..... Agricultural engineer
Dr. Fang S. Lai ..... Research chemical engineer
Charles R. Martin ..... Agricultural engineer
Duane E. Walker ..... Electronic engineer
Larry E. Shackelford ..... Engineering technician
Nelva H. Wilcox ..... Clerk-typist
George M. Wyatt ..... Engineering technician
*David F. Aldis ..... Research assistant
*Gary Breipohl ..... Graduate research assistant
*David W. Garrett ..... Graduate research assistant
*Jon J. Held ..... Research assistant
*Earl W. Hilchey, Jr. ..... Engineering draftsman
*Bamidele O. Solomon ..... Graduate research assistant
*Jean S. Waters ..... Research assistant
Milovan Panić ..... Visiting scientist
Gosa Industries
Beograd, Yugoslavia

Grain Quality and End-Use Properties Research Unit

Prof. Karl F. Finney ..... Research leader and research chemist
Lerance C. Bolte ..... Food technologist cereal
Dr. Berne L. Jones ..... Research chemist
Dr. George L. Lookhart ..... Research chemist
Merle D. Shogren ..... Research food technologist
Bernadine M. Eichman ..... Biological technician
Michael H. Klinker ..... Agricultural research technician
*Margo S. Caley ..... Research assistant
*D. Blake Cooper ..... Research assistant
*Douglas C. Fecht ..... Research assistant
*Roxanne M. Fridirici ..... Research assistant
*Tresa D. Jones ..... Research assistant
*Harriett H. Meinecke ..... Research assistant
**Francis L. Smith ..... Laboratory technician
Mr. Osamu Natsuaki ..... Visiting scientist
Shikishima Baking Co., Ltd.
Tokyo, Japan
Dr. Jerry Kaczkowski ..... Visiting scientist
Institute of Plant Biology
Warsaw, Poland

Grain Quality Characterization Research Unit

Dr. Byron S. Miller ..... Research leader and research chemist
Dr. William M. Lamkin ..... Research chemist
*John W. Hughes ..... Research assistant

Economic Analyses (ESCS)

Dr. Floyd F. Niernberger ..... Agricultural economist
Dr. Walter G. Heid, Jr. ..... Agricultural economist
Dr. L. D. Schnake ..... Agricultural economist
Margie L. Burk ..... Clerk-typist
*Joan Shull ..... Research assistant

Maintenance Staff

Chester D. Litle ..... Refrigeration and air conditioning mechanic-foreman
Robert L. Welfringer ..... Refrigeration and air conditioning mechanic
Terry B. Cassity ..... Electrician
Donald D. Brill ..... Custodian
Kerwin K. Crabs ..... Laborer
Lacy Lowery ..... Custodian

*In cooperation with the Kansas Agricultural Experiment Station.
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